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Chamaedorea Palm Frond Commercialization and Certification Considered from a Smallholder Livelihood System Perspective

David S. Wilsey · Peter E. Hildebrand

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Abstract *Chamaedorea* palm frond (xate) certification has been broadly promoted throughout Mesoamerica as a means to foster the integration of forest conservation and economic development. This study examined the feasibility of xate commercialization and certification at the scale of the extractor livelihood system in an ejido in the Chinantla region of Oaxaca, Mexico. Ethnographic methods were used to collect livelihood system data. These data were used to develop an ethnographic linear program (ELP) model of extractor households to analyze the effects of palm frond management and marketing scenarios on their livelihoods. Three necessary conditions for the feasibility of certification were hypothesized: two related to extractor livelihoods and another related to market fluidity. Livelihood outcomes supported the notion that resource sustainability and economic development are not mutually exclusive, and provided support for xate certification as an intervention oriented toward the integration of these objectives. In contrast, the model revealed an unfavorable discrepancy between xate supply and the level of demand expressed by an interested buyer. This shortfall represented a substantial obstacle to the feasibility of xate certification in the community. Low demand fulfillment suggested that xate certification ultimately represents an infeasible strategy for the community, irrespective of the observed livelihood and conservation benefits. Results highlighted the importance of understanding household objectives and market context in local decisions to pursue NTFP certification. We suggest that the community's

D. S. Wilsey (✉)
Forestry, Extension Center for Food, Agriculture, and Natural Resource Sciences,
University of Minnesota, Minneapolis, MN, USA
e-mail: dwilsey@umn.edu

P. E. Hildebrand
Food and Resource Economics, Institute for Food and Agricultural Sciences, University of Florida,
Gainesville, FL, USA

objectives would best be served by engaging neighboring communities in a cooperative and controlled effort to augment regional supply.

Keywords Certification · Chamaedorea · Livelihoods · NTFP · Oaxaca · Palm · Scenario model · Xate

Introduction

Over the past 25 years, commercialization of non-timber forest products (NTFP) has been promoted as a reconciliatory strategy (Arnold and Ruiz Perez 1998; Nepstad and Schwartzman 1992; Neumann and Hirsch 2000), one that supports forest conservation and the livelihood needs of forest-based populations. Ostensibly, NTFP commercialization reconciles conservation and development objectives by increasing the economic value of intact forest to local inhabitants, thereby providing an incentive for conservation (Angelsen and Wunder 2003; Fearnside 1989; Peters et al. 1989; Wollenberg and Ingles 1998). *Certification* of NTFP has emerged more recently as an adaptation of commercialization and its proponents anticipate that certification standards can bridge some of the environmental, economic, and social pitfalls that have impeded the success of commercialization efforts. The search continues, unabated, for NTFP with commercial potential and for contexts amenable to commercialization and conservation.

Certain palm fronds of the genus *Chamaedorea* are harvested in Mexico and Guatemala for use as foliage in floral arrangements and for Palm Sunday (CEC 2002). This commercially defined group of species is often generically referred to as *xate* (pronounced sha-tay). Commercial xate harvest for export markets began in the 1950s, when the fronds were being used to wrap flowers and were discovered to be well suited to transport and post-harvest application in floral arrangements. Enthusiasm for certification of xate extraction and trade is fueled by a production trend, from extraction to cultivation, and the success of pilot and regional sales of fronds marketed as sustainably harvested and fairly traded. Proponents hope that certification represents a means to foster forest conservation and economic development objectives in high biodiversity regions where commercially important species of palms are endemic, such as Guatemala's *El Petén* and Mexico's *Selva Lacandona,* the *Sierra Sur* of Chiapas, and the *Chinantla* of Oaxaca.

General success of forest product labeling (i.e., certification) efforts has been limited by an absence of markets for which supply and demand are reasonably balanced (Overdevest 2004; Pierce et al. 2003). Unfortunately, in the context of diverse and dynamic small-scale forest livelihoods, estimates of commercial supply are much more than simple functions of natural resource populations and harvest rates. Numerous and complex factors influence local livelihood strategies, which in turn influence supply, and consequently, conservation and development outcomes of NTFP-oriented interventions (Nygren et al. 2006). Some important considerations include traditional resource knowledge and uses, local natural resource management practices, prevailing livelihood systems, value chain structure, and availability of market information. If anticipating the success of interventions such as certification

requires a better understanding of the potential relationship of supply to demand, it follows that the need for improved estimations of potential supply necessitates a more nuanced understanding of the diversity and dynamics of forest livelihood systems and strategies.

The objective of this study was to develop and test two hypotheses related to livelihoods and one hypothesis related to market fluidity using an ethnographic linear program (ELP) to model a xate-harvesting community's livelihood system. The hypotheses derive from and rest upon Marshall et al.'s (2006) assumption that commercial interventions should not negatively affect livelihoods of extractors. The three hypotheses suggest that, to be feasible, certification must:

1. Positively affect extractor household livelihoods.
2. Benefit, or at least not disadvantage, the poorest extractor households.
3. Be viable with respect to supply and demand.

Our expectation was that a more profound understanding of the local livelihood system and strategies of diverse households would improve our estimations of the potential outcomes of xate certification efforts in the community of interest, and would likely suggest possible steps for improving the feasibility of such interventions. At the outset of this study no formal or informal commercial arrangement existed between the community and a buyer and thus, no estimate of demand against which supply estimates could be compared. Following data collection, and perhaps an outcome of that process, a buyer made a formal purchase offer to the community. The offer presented was the minimum feasible purchase quantity, i.e., minimum feasible demand, and was used herein to interpret the results of the model.

Materials and Methods

This study employed a *livelihood system* perspective to consider the means by which households manage resources to meet objectives within a particular ecological, economic, and social context (Sellen et al. 1993). Livelihood systems research is a diagnostic process comprised of diverse methods through which researchers elicit a better understanding of households, their decisions, and decision-making processes (Collinson 2000). A livelihood system is the composite of activities available to all households to secure their livelihoods (Hildebrand et al. 2003; Hildebrand and Schmink 2004). By extension, *livelihood strategies* are the specific set of activities in which a household engages, chosen from those comprising the livelihood system (Hildebrand and Schmink 2004). Within a given system, livelihood strategies can be both diverse and dynamic.

Study Area and Context

La Soledad de Juarez (henceforth, Soledad) is an *ejido*, one of three types of rural property initially defined through Article 27 of the 1917 Mexican constitution

(Mendivil 1996). Ejidos are collectivized land grants that were primarily made to landless groups of varied ethnic backgrounds. An ejido is, in principle, property of the nation that is granted to a community of peasants in usufruct. It is not communal property, but rather an obscured form of private smallholding with a few defining characteristics (Bartra 1993). First and foremost, ejido lands are endowed by the state rather than purchased. Additionally, land usage is subject to restrictions and limitations including Mexican citizenship, eligibility through residence, the requirement to personally work the land, and the absence of other forms of ownership.

Soledad was formed in 1998 with the endowment of 1,811 ha to 52 landholders, or *ejidatarios*. These individuals collectively form the community's governing body. The predominant Soledad livelihood system combines subsistence agriculture and agroforestry, coupling these activities with limited, commercial non-timber forest product extraction and wage-generating employment at the local, regional, and national levels. Some Soledad households receive institutional support from various branches of the Mexican government in the areas of agriculture and social development (e.g., schooling, nutrition, and healthcare). International labor migration and remittances, in general, have not been reported to be substantial sources of income for the community. Historically, palm frond harvest has been an important activity within this livelihood system. The livelihood system modeled was that of the landholders, or *ejidatarios*, of Soledad. More specifically, we constructed the livelihood model based on the livelihood system of those landowners for which palm frond harvest was a known activity. Within this group, livelihood strategies varied by extent of participation in the activities described above, more so than by variation of the activities themselves.

Soledad is one of several ejidos in the Rio Cajonos valley—situated within the Chinantla region of Oaxaca, Mexico (Fig. 1) and well known for its abundance of *Chamaedorea* palm. Neighboring ejidos include Monte Tinta, San Antonio de las Palmas, Luis Echevería, and Plan Martín Chino, among others. Although politically distinct, the ejidos may be connected socially or by lineage. For example, prior to 1998 the ejidatarios of Soledad were the landless offspring in Plan Martín Chino. Today, the two communities share a single municipal zone. It is noteworthy that the livelihood systems of Soledad and Plan Martín differ substantially due to the virtual absence in Soledad of pasture and thus, large livestock production. Finally, natural resource management on ejido land is politically distinct, but informally governed by voluntary participation in the Regional Council for Natural Resources of the Papaloapan Watershed (CRRN-P, in Spanish).

Mexico's Forestry Law[1] formally established procedures for legal, commercial non-timber forest product harvest. These procedures require, among other things, a forest management plan prepared by a nationally registered forester and a statement addressing all unresolved territorial disputes with neighboring communities. Additional legislation[2] outlines the conditions for legal palm frond harvest, transport, and storage.

[1] Article 56 of the 2010 *Regulations of the General Law of Sustainable Forest Development*.

[2] NOM-006-RECNAT-1997.

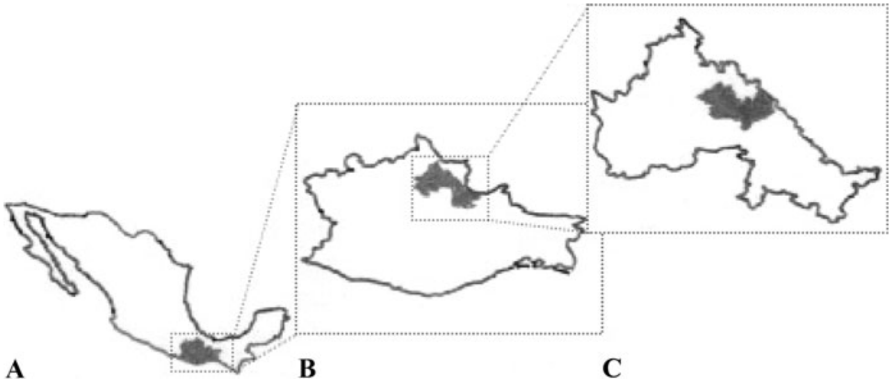

Fig. 1 Location of Soledad de Juarez. **a** Oaxaca, Mexico. **b** Chinantla, Oaxaca. **c** Jacatepec, Chinantla

Model Specifications

Linear programming (LP) is an optimization procedure that maximizes (or minimizes) an objective function (household goal) subject to a set of constraints (e.g., consumption requirements) and available resources (e.g., labor, land). Ethnographic methods were used to collect livelihood system data, which were then used to develop an ethnographic linear program (ELP) model of extractor households to analyze the effects of palm frond management and marketing scenarios on their livelihoods. The general structure of the ELP is summarized as follows:

$$\text{Maximize(or Minimize)} : \prod = \sum_j C_j X_j (j = 1, \ldots, n)$$

$$\text{Subject to:} \sum_j A_{ij} X_j \leq R_i (i = 1, \ldots, m)$$

$$\text{And } X_i \geq 0$$

where $\prod$ is the household objective to be optimized; X_j is the vector of livelihood activity variables (livelihood strategies) to be determined; C_j is the cost (debit) or return (credit) of each of the n activities; A_{ij} is the set of technical coefficients for each activity j and resource/constraint, i; and, R_i is the set of m constraints.

Model Inputs

The framework for the livelihood system emerged from a rapid assessment, or *sondeo* (Hildebrand 1981), completed in the community (Wilsey 2008). This framework focused subsequent collection of livelihood data, which were principally collected through two palm-harvester workshops and in-depth conversations with three households. Livelihood data from these sources were compared with and, in some cases, complemented by data from existing regional (De Teresa 1998,

1999; INI 2004) and community level studies (Angel 2003; Grupo Mesofilo 2004; MIE 2004), which also provided valuable context. Much livelihood activity in Soledad was production-oriented: the cultivation of crops, palm and fuel wood harvest, and off-farm labor. Activities associated with the household reproduction were also included. Actual resource use varied by household but inputs and outputs associated with a unit of activity generally did not (e.g., planting maize).

General constraints to the model addressed availability of agricultural land (riparian and upland), supply of and demand for household labor and cash, and requirements for household food consumption and cash needs.

The majority of Soledad's land is not well suited to the cultivation of traditional and commercial food crops. Six percent (111 ha) of Soledad's land endowment was designated suitable for agriculture, only 16 ha of which were riparian terrain suitable for planting during the dry season (MIE 2004). It was estimated that only 20 of the remaining 95 ha of non-riparian, agricultural land were cultivated (MIE 2004, p. 15), averaging 0.4 ha per household. Thus, on average, Soledad's ejidatarios had land endowments of 0.3 ha of riparian agricultural land, 0.4 ha of upland agricultural terrain, and approximately 600 m^2 in a plot that included a home and garden, or *solar* (MIE 2004). Endowed agricultural land was managed exclusively by the *ejiditario*, much like privately owned land. Typically, agricultural land was used to produce some combination of milpa (corn, beans and squash), chilis, yuca, and jicama. For the purposes of modeling, it was assumed that each household contained one ejidatario, and had access only to that individual's agricultural land.

In addition, ejidatarios typically had access to roughly 6.5 ha of utilizable forest terrain. Forest in conservation status could not be used for agricultural activities, but was accessible to all community members for forest product collection. NTFP such as xate, game, fiber, and fuelwood were freely gathered and hunted by ejiditario households within assigned forest parcels, and by all households in unassigned, accessible forested areas. The primary forest-oriented livelihood activity was xate harvest. Fuelwood gathering was also important.

Total available household labor was measured in days (*jornales*) and depended on household composition. This value was affected by several empirically driven assumptions, such as a six-day workweek and reductions to the available workdays due to seasonal activities and events (e.g. school, holidays). The model used a double-entry labor accounting system designed so that the predominant pattern of pooled, general household labor could be applied to the majority of activities without ignoring (infrequent) constraints imposed when activities required the labor of a particular (type of) individual (e.g., household reproduction labor by females).

The model year was divided into two agricultural seasons, representing the rainy and dry weather patterns. Each season was further sub-divided into three asymmetrical periods, which stemmed from a need to differentiate three important, resource-utilizing periods: land preparation and planting (2 months), crop maintenance (3 months), and harvest (1 month).

The model also contained *technical constraints*. Production land for associated crops was "linked" to ensure that crop associations were maintained as empirically observed. A palm population estimate was conducted by a nationally approved forestry engineer (Salgado C 2001) and provided palm population and legal xate

Table 1 Operational elements of xate market scenarios

Concept	Unit	Xate market scenario			
		S1	S2	S3	S4
Price	$US/roll*	8.90	8.90	10.65	10.65
Demand	Rolls/household/year	0	45	46	36

* 1 roll = 600 fronds

harvest levels. Constraints on xate harvest varied by scenario and derived from the estimated palm population, percentage of waste in the harvest, and population sustainability requirements. Palm harvest was allocated equally among the 25 palm frond harvesting households. Commercialization of some crops was constrained with the intent to simulate low actual levels of demand described by community members; participation in local wage-labor and NTFP harvest were similarly constrained.

Market/Management Scenarios

Four palm frond market/management scenarios (Table 1) were used, operationalized through two terms: *price* and the *maximum supply*. Price was the amount (US$) paid for one roll[3] of xate. Maximum supply was the maximum number of rolls of xate harvestable by each household, given the resource management requirements imposed by either the palm population or marketing strategy. In the model, these values changed with each scenario.

S1. 'Current Market' Scenario

This scenario characterized the region at the time of this study. Maximum supply was one-fifth of the estimated five-year harvest, which was based on an estimate of the population of palms at a commercially viable age (Salgado 2002; personal communication). The definitive attribute was the absence of demand, operationalized using a zero price, although it was noted that itinerant buyers made sporadic frond purchases. Recent abatement of demand was explained as the combined effect of increased buyer uncertainty with regard to supply coupled with rising transportation costs. Additionally, a longtime intermediary/buyer was anecdotally reported to have left the region.

S2. 'Historical Market' Scenario

In this scenario maximum supply remained the same as in the 'current market' scenario. Frond price reflected the traditional amount paid for unsorted palm fronds and was consistent with the amount paid by itinerant buyers in the region (De los Santos, personal communication). Traditionally, the price paid to harvesters was

[3] 1 Roll = 600 fronds.

based on frond volume, measured in *gruesas*,[4] without substantial consideration for frond quality. In reality, the historical market scenario was a livelihood artifact that would likely be untenable in the present market and regulatory context. Nevertheless, it provided a point of reference for future comparison of the benefits/costs of interventions based upon product and process standards.

S3. 'Quality Market' Scenario

Recent commercialization efforts throughout the region have emphasized quality, supplied in consistent quantities. Prices are higher in the quality-driven system, but higher prices do not represent a premium. They are a price adjustment that reflects additional value. In this scenario, the higher price per roll reflected the potential incentive being offered for delivery of a consistent weekly supply of quality fronds (i.e., no waste; Everett and Blankenship, personal communication). To account for the decrease in waste, the maximum supply was reduced through a 20% reduction to the total number of harvestable fronds. An important assumption was that harvesters would do the quality sorting, through selective harvesting practices. The technical assumption of a one roll/day harvest rate remained, based on a second assumption that harvesters would require as much time to collect 600 quality fronds as to collect 750 fronds containing 20% waste. The net effect was an increase to the maximum supply of one roll per harvester per year.

S4. 'Certified Market' Scenario

Palm frond harvest in naturally occurring (uncultivated) populations was regulated by Mexican law NOM-006, which required that at least 20% of the mature plant population be left untouched to ensure reproductive success and long-term population health. The operational effect of this sustainability mandate was a 20% reduction in the number of harvestable plants. In contrast to the quality market scenario, where quality restrictions were offset by increased harvest efficiency, the sustainability restriction resulted in a proportional net decrease in maximum supply. Price remained unchanged from the quality scenario. The market benefit of "certification" accrues to the community in the form of market access (Sedjo and Swallow 1999), rather than price premiums. This scenario most nearly approximated a standards-driven xate market in Soledad. It was the only scenario that provided a price incentive and/or ensured market access, that addressed the buyer's concern for a consistent offering of quality product, and that incorporated the state's legal mandate for sustainable resource management.

Household Composition

Household composition was one facet of community diversity and has been recognized as an important factor in the formation of household livelihood strategies

[4] In Soledad, typically 1 gruesa = 120 fronds. This equivalency varies across the geographic range of harvest.

Table 2 Household composition scenarios for Soledad de Juarez, Oaxaca

Individual	HH I $N = 3$	HH II $N = 3$	HH III $N = 15$	HH IV $N = 4$
Adult, male	1	1	1	1
Adult, female	1	1	1	1
Adolescent, male	0	0	1	2
Adolescent, female	0	0	2	1
Youth, male	0	2	1	0
Youth, female	0	1	1	0

(Cabrera et al. 2005). The model used four household composition scenarios, representing stages in household development (Table 2). Each household was a construct developed using actual composition data from the 25 Soledad households known to harvest palm fronds at the time of this study. The four household stages were: no children (HH I), young children (HH II), mixed-age children (HH III), and older children (HH IV).

For each stage, the household composition used in the model was the average number of individuals, for each gender, of the following age groups: adults, adolescents, and youth. Averages were calculated using only the households classified within each particular stage. The predominant household (HH III) was nuclear, had mixed-age children, and contained seven members. Fifteen (60%) of the 25 were so classified. This size household was consistent with the average Soledad household (MIE 2004).

Model Output

The *palm market/management* and *household composition* scenarios described above framed a solution table for the model. The solution table was completed for each of two objectives: (1) to *maximize discretionary year-end cash* and (2) to *minimize migration periods*. Thus, two solution sets were generated, each representing the optimal outcome (and associated livelihood strategies) given the specified household composition, palm market/management scenario, and household objective. Optimal livelihood strategies were operationalized through the allocation of three critical household resources—land, labor, and cash—to all available livelihood activities.

One component of each solution was the number of days that a household dedicated to the harvest of palm fronds. For each palm market/management scenario and for both model objectives, the number of days harvested by each household was aggregated to the community level, providing an estimate of the total potential supply of palm fronds. The aggregate amount harvested in the model represented the supply and was considered alongside the (imposed) maximum supply as well as the buyer's expressed demand for 100 rolls per week, or 5,200 rolls annually.

Results

It was hypothesized that *certification positively affects household livelihoods*. All market scenarios produced livelihood benefits relative to the current scenario (S1) and did so for both household objectives (Fig. 2). Year-end discretionary cash values more than doubled for all household compositions when the model was set to maximize that value (Fig. 2a). Set to minimize migration, the periods spent working outside of the community decreased relative to the current scenario for each of the three households for which migration is necessary in the absence of palm harvest. For HH II, palm commercialization of any form obviated the need for migration (Fig. 2b).

Positive livelihood effects were somewhat diminished by the addition of quality standards (S3) as well as sustainability standards (S4). However, the relatively small differences in year-end household cash *between* the commercialization scenarios (II, III, and IV) were inconsequential compared to the overall increase in year-end cash that resulted from the shift from no market (S1) to some form of commercialization.

It was hypothesized that *certification will benefit, or at least not disadvantage, the poorest households*. In this study, the poorest households were identified as those for which the year-end cash value was the lowest or for which migration requirements were the highest in the current market scenario. For both livelihood objectives, the shift from the current scenario to some form of commercialization generated benefits for households that differed in absolute measure, but had relatively proportional effects among household types (Table 3).

It was hypothesized that *certification is viable with respect to supply and demand*. The use of the two household objectives generated a range of xate supply at the community level, which provided a more nuanced overall picture of potential supply. Of particular interest was the supply for the certification scenario (S4), which given the observed social, economic, and legal context most closely approximated the conditions of any future harvest. At the low end of that range (minimizing migration) the community supplied about 432 rolls in a year; and at the high end (maximizing year-end cash) the community achieved the full 910 roll annual allowable harvest. Annual demand was 5,200 rolls per year.

A sensitivity analysis established effects on the model results of three factors: household expenditure, xate price, and the estimate of palm population. The

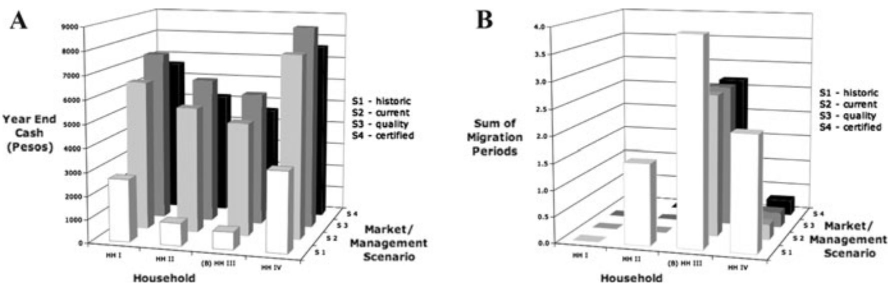

Fig. 2 Model output by scenario. **a** Household year-end cash under the 'maximize year-end cash' objective. **b** Sum of household migration periods under the 'minimize migration' objective

Table 3 Livelihood outcomes under the certified market scenario (S4) and in comparison to the current market scenario (S1), by household composition

	HH I	HH II	HH III	HH IV
Year-end cash, S4	6,624	5,190	4,652	7,626
Percent change from S1 (%)	148	444	520	123
Migration, S4	0.0	0.0	2.7	0.3
Percent change from S1 (%)	0	−100	−31	−86

Table 4 Sensitivity to selected factors of Soledad's potential range of xate supply (in rolls) under the certified market scenario (S4)

	ELP model objective function	
	Minimize migration	Maximize year-end cash
Basic model, S4	432	910
Household expenses + 25%	643	910
Palm price + 20%	362	910
Palm population +20%	432	1,100

* 1 roll = 600 fronds

sensitivity analysis was conducted under the quality/sustainability market scenario (S4). Any model requires approximation and assumptions. In this case, the estimate of incidental *household cash expenditures* was the least informed, due to time constraints and the universal challenges inherent to collecting reliable household income and expense data. Because households can forego cash expenditures in difficult times, through reduced consumption and other procurement methods such as informal exchange, we chose to set household cash expenses at a low value. With the objective to maximize year-end cash, increasing household cash expenditure by 25% affected the livelihoods by equivalent reduction to year-end cash. Xate harvest (supply) and associated income were unaffected by the change. In contrast, the increase in expenditure with the objective to minimize migration led to an increase in xate harvest (supply) for all households. Soledad's annual xate supply increased by 49%: from 432 rolls to 643 rolls (Table 4).

Xate prices in the model reflected the historical and current amount paid for unsorted fronds (S1 and S2) and the price offered in the negotiation between Soledad and a potential buyer (S3 and S4). A price change equivalent to the increase in price from the unsorted harvest to quality harvest (20%; S2–S3), resulted in a price per roll of $US 12.7. At the higher price and with the objective to maximize year-end cash, xate harvest remained unchanged: harvest levels under this objective were already at the maximum allowable level. With the objective to minimize migration, the price increase led to a decrease in xate harvest (supply) for all households. Annual xate supply decreased 16%: from 432 rolls to 362 rolls (Table 4).

Finally, estimates of total *palm population* affected the maximum allowable, harvests in all four xate market/management scenarios. A 20% increase in estimated palm population resulted in an increase to the upper end of Soledad's maximum total supply: from 910 rolls to 1,100 rolls, or from 18 to 21% of the buyer's expressed demand (Table 4). An increase in palm population might be achievable through enrichment planting.

Discussion

Results from the ELP model suggested that certification could produce beneficial livelihood outcomes, but revealed a limitation common to all the tested market/management scenarios. While the two livelihood hypotheses were supported, the market hypothesis was not. Although livelihood and supply outcomes differed between the two household objectives, all else being equal, their interpretation with respect to the tested hypotheses did not. First, certification improved Soledad livelihoods, whether measured by increased year-end cash or decreased migration. Second, certification improved livelihoods for each of four household compositions; i.e., there were no clear winners and losers. Third, livelihood improvements persisted as commercialization was constrained, first by quality standards and then by sustainability standards. These outcomes support the notion that resource sustainability and economic development are not mutually exclusive. Taken together, these findings offer support for the socio-economic feasibility of xate certification in Soledad.

In contrast, the model revealed an unfavorable discrepancy between potential supply and expressed demand. This shortfall represents a significant obstacle to the feasibility of certified xate in the community. Under the certification scenario (S4), households supplied only 8–18% of expressed demand. This range reflects differences in household participation in harvesting that correspond with the two household objectives used in the model. A better understanding of household objectives, the relaxing of constraints, and adjustments to the model's assumptions might narrow the range of supply generated under the two household objectives, but the large discrepancy between supply and demand is a reality that looms heavily over the community enterprise. This result underscores the well-documented importance of market fluidity, or supply and demand parity, in commercialization efforts (Neumann and Hirsch 2000; Overdevest 2004; Panayotou and Ashton 1992).

It is important to recognize, however, that practical considerations shaped aspects of this study. One was the structuring of commercial xate harvest as a year-round livelihood activity. This reflected the buyer's expressed preference for a stable weekly supply to buffer existing supply variability. Other arrangements might represent feasible alternatives and should be explored further. A more intensive seasonal harvest, corresponding with the Easter demand peak, might serve to concentrate harvest and thus increase fulfillment of demand. Using the estimated range of annual supply generated by the model (432–910 rolls), Soledad could potentially supply the buyer with 100 rolls/week for a period of four to 9 weeks.

The feasibility of this approach would depend on the availability of household resources for harvest during this period, but was not tested.

Another choice was to focus on a single community. The results presented above must be interpreted with the knowledge that Soledad does not exist in isolation; rather, it is one of several communities situated within a valley well endowed with xate. The proximity of other communities with the palm resource justifies a renewed, but tempered optimism for the feasibility of xate certification in the region. Inter-community cooperation has the potential to enhance the feasibility of the strategy, at least from the perspective of supply and demand parity. Cooperation might also enlarge the footprint of any positive conservation and development effects related to certification.

Results of the sensitivity analysis also provided insight into the potential feasibility of certification and other market interventions. The sensitivity analysis demonstrated that *xate price* was inversely related to potential supply under the 'minimize migration' objective. Households motivated by this objective would likely harvest fewer fronds in response to a price premium generated by certification, leading to a diminished quantity at the low end of the supply range. This suggests that the challenge of reducing the gap in the supply range would unlikely be overcome through the use of price premiums, which benefit households minimizing migration by allowing them to harvest less and still meet household needs, thereby undermining the feasibility of commercial activity.

The model results and sensitivity analysis also demonstrated a positive relation between the upper end of the supply range and the estimate of the palm population, a figure unlikely to change appreciably over the short term. Yet over time, palm populations may be subject to the influence of intensification. In some contexts, enhancement planting might be an appropriate strategy for increasing commercial viability (Michon and de Foresta 1998). However, intensification might also displace existing understory vegetation, directly conflicting with biodiversity conservation objectives (Browder 1992).

Conclusions

In Soledad de Juarez, the broader Chinantla region, and beyond, the question of whether certification represents a feasible intervention rapidly leads to the fundamental issue of supply and demand parity. In Soledad, supply was shown to be a function of the palm population, but also of the households' resource availability, livelihood strategies, and objectives. These are and will remain important topics for future research on market interventions for the reconciliation of conservation and development objectives.

In the case of Soledad de Juarez and the Chinantla, the most challenging question ultimately may be whether adequate social cohesion exists to allow communities to work in cooperation to positively influence the region's supply to achieve an economy of scale. The model developed here could be useful in facilitating this conversation and in broader investigations of the production capacities of households and communities in this and other regions. We conclude that Soledad's

xate commercialization (and certification) objectives would best be served by engaging neighboring communities in a cooperative and controlled effort to augment regional supply, thereby decreasing the observed gap between regional supply and expressed demand.

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